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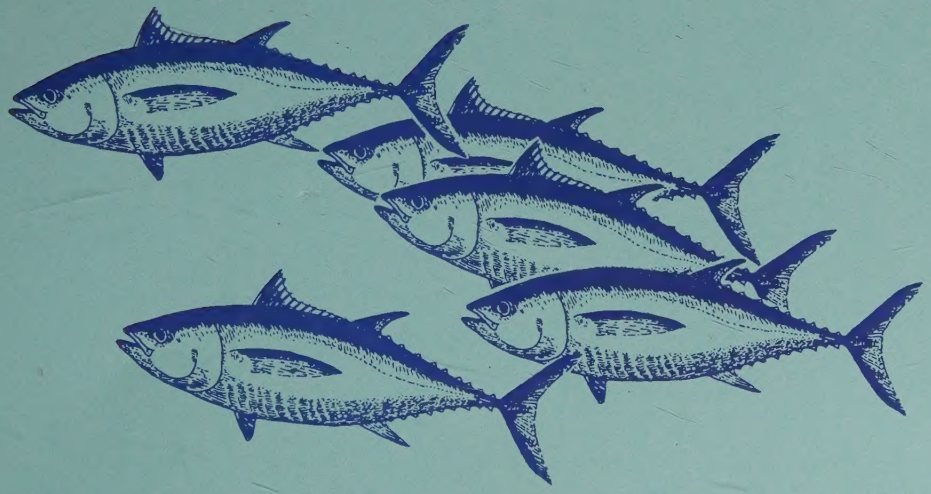
Director's Report to the 52nd Tuna Conference

On Tuna and
Tuna-Related Activities at the
Southwest Fisheries Science Center
for the Period May 1, 2000
to April 30, 2001



ADMINISTRATIVE REPORT LJ-01-02

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DIRECTOR'S REPORT TO THE 52nd TUNA CONFERENCE ON TUNA AND TUNA-RELATED ACTIVITIES AT THE SOUTHWEST FISHERIES SCIENCE CENTER FOR THE PERIOD MAY 1, 2000–APRIL 30, 2001

Southwest Fisheries Science Center
National Marine Fisheries Service, NOAA
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ADMINISTRATIVE REPORT LJ-01-02

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INTRODUCTION

The 2001 Director's Report to the Tuna Conference highlights Southwest Fisheries Science Center scientific research relating to tropical tunas, albacore, billfishes, and sharks and protected species associated with their fisheries. The work was conducted during May 2000 through April 2001 by the Center's La Jolla and Honolulu Laboratories.

The biological, economic, and oceanographic research concentrated on providing quality fishery analyses and management information to the regional fishery management councils, international scientific working groups and committees, and the National Marine Fisheries Service Southwest Region and headquarters. Major tuna-related activities included stock assessments, socio-economic research, research on interactions between fisheries and protected species, and mathematical modeling of fish movements and fishery interactions. This data collection and analysis is aimed at ensuring that U.S. and world fisheries, populations of protected marine species, and coastal and marine habitats remain at sustainable and healthy levels and that the most effective fishing regulations and international treaties are carried out.

During the year, Center scientists also were active in tuna-related international forums, including the Interim Scientific Committee for Tuna and Tuna-like Species in the North Pacific, the Standing Committee on Tunas and Billfish, and the Multilateral High-Level Conference on the Conservation and Management of Highly Migratory Species in the Western and Central Pacific.

The following sections provide informal summaries of activities and events that have taken place at the Center since last year's Tuna Conference.

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I. CENTRAL AND WESTERN PACIFIC TUNA FISHERIES

U.S. Purse-Seine Fishery Annual Report – The National Marine Fisheries Service (NMFS or NOAA Fisheries) monitors the U.S. purse-seine fishery for tropical tunas in the central and western Pacific Ocean as part of U.S. obligations under the 1988 South Pacific Tuna Treaty. Each year, the NMFS Southwest Region and Center review data collected from the fishery and assess the health of Pacific tropical tuna stocks. Information on the year 2000 U.S. fishery and status of the stocks was presented in March 2001 at a meeting of treaty participants held in Western Samoa. These annual discussions focus on operational aspects of the treaty, such as the number of licenses, closed areas, vessel reporting requirements, observer placements, and statistics collection.

During 2000, 33 U.S. purse-seine vessels fished in the central and western Pacific. The 2000 U.S. catch of yellowfin, skipjack and bigeye tunas was 125,000 metric tons (mt), the lowest level since 1988. This record low catch resulted from several factors. An oversupply of light meat tuna and record low tuna prices caused the U.S. purse-seine fleet to voluntarily reduce fishing effort and vessels to remain in port for up to four months of the season. The U.S. fleet also concentrated more fishing effort on schools of free-swimming tunas and less effort on schools of tuna associated with fish aggregating devices (FADs) or floating objects. Free-swimming schools usually contain larger fish and higher proportions of yellowfin tuna, which command higher prices. However, sets on free-swimming schools are only half as successful in landing a catch as sets on schools of fish associated with FADs, and this lower success rate weakened many of the U.S. fleet's performance indices. The catch rate (catch per unit of effort or CPUE) in 2000 decreased to 27 mt per day fished from 34 mt per day fished in 1999. The average trip length increased to 56 days in 2000, up from 42 days in 1999.

Sampling of the U.S. fleet's catch continued in 2000. NOAA Fisheries collected fishing logbooks and landings data from 100% of the U.S. tuna purse-seine fleet, took length measurements of nearly 64,700 fish, and took species composition samples from 31,100 fish. Overall, the central-western Pacific tropical tuna stocks appear to be in good health.

FAD Fishing Examined – Research on the effects of drifting FADs on the fishing efficiency of the U.S. tuna purse-seine fleet culminated in publication of a paper on "The impact of FAD innovation on the performance of U.S. tuna purse-seine operations in the Pacific Ocean" (Sakagawa 2000). According to the study, the use of drifting FADs has significantly improved the performance of the U.S. purse-seine fleet. FADs have a higher success rate (96%) in catching tunas that results in an average catch rate of 37 mt of tuna per successful set, as compared to conventional fishing techniques (53% success rate and average catch rate of 42 mt of tuna per successful set). This increased success rate using drifting FADs has resulted in increased landings of tuna and shorter fishing trips. The results of the study have been used to explain the basis for a significant increase in the supply of tuna on the current world market and highlight a need for controls on fishing capacity in the central and western Pacific tuna fishery.

Tuna Fishing Capacity Studied – The La Jolla Laboratory is participating in a new project to estimate fishing capacity in the central and western Pacific tuna purse-seine fishery over a 10-year period. Purse-seine fishing capacity from all distant-water fishing nations, including the United States, Japan, Korea, Taiwan, and Spain, will be evaluated by the project. The project also will attempt to measure growth in total factor productivity over this time period and relate the results to changes in the fishery, such as the growing reliance on FADs. The fishing capacity

project is part of a larger federal and industry effort to address fishing capacity in the region and develop capacity-oriented regulations for the fishery. Capacity management could come through various measures, including a limited entry or vessel quota system or a limit on fishing time.

Fisheries Acoustical Studies – The Advanced Survey Technologies group at the La Jolla Laboratory is conducting a variety of acoustics studies on large pelagic fishes. In one study, underwater sounds generated by yellowfin tuna and bluefin tuna were recorded and studied to explore the possibility of passive acoustical detection. Tuna vocalizations were audio- and video-recorded at the Monterey Bay Aquarium in California and the Maricultura del Norte in Ensenada, Baja California, Mexico. Results of this study will be discussed in a poster presentation at this year's Tuna Conference. Another study involves the characterization of low-frequency sound generated from individual albacore tuna and their aggregations.

MHLC Support – Scientists at the SWFSC have been involved in the Multilateral High-Level Conference on the Conservation and Management of Highly Migratory Fish Stocks in the Western and Central Pacific Ocean (MHLC) since its inception in December 1994. Their role has been largely as scientific advisors to the U.S. delegation and a source for scientific information and advice on the stocks and fisheries. In September 2000, after seven meetings, the conference concluded with an agreement that will establish an international commission to conserve and manage highly migratory fish stocks throughout the western and central Pacific. Countries that approved the text were Australia, Canada, Cook Islands, China, Federates States of Micronesia, Fiji, France, Indonesia, Kiribati, Marshall Islands, Nauru, New Zealand, Niue, Palau, Papua New Guinea, Philippines, Korea (with reservations), Samoa, Solomon Islands, Tonga, Tuvalu, United States, and Vanuatu. New Caledonia and Chinese Taipei (Taiwan) also approved the text.

This regional arrangement will come into force when a sufficient number of countries ratify the text, but principally when three countries situated north of 20°N and seven countries situated south of 20°N ratify the text. There is high expectation that a sufficient number of countries will ratify and the arrangement will enter into force within a few years. Preparatory conferences are, therefore, being planned to develop processes to allow the new commission to effectively operate, without undue delay, when the agreement enters into force. The first such preparatory conference was held in Christchurch, New Zealand, in April 2001. The focus of the conference primarily was on administrative matters and on organizing work plans for two working groups on organizational structure, budget, and financial contributions and on scientific structure and provision of interim scientific advice. An SWFSC scientist participated in the sessions of the latter working group.

II. PACIFIC ALBACORE FISHERIES

Albacore Fishery Data Summarized – The La Jolla Laboratory's Fisheries Resources Division routinely processes data for the U.S. albacore fishery. Data are obtained from west coast states, logbooks collected from cooperating fishermen, and length-frequency of albacore in the catches of U.S. troll and baitboat vessels. The information is essential to assess the condition of Pacific albacore stocks and to monitor fishery performance. Data for the 1998-99 South Pacific and 1999 North Pacific fishing seasons were published in SWFSC Administrative Report LJ-00-06 and distributed to cooperating fishermen and others.

The 1999 U.S. catch of North Pacific albacore was 11,200 mt, a decrease from the 14,000 mt caught in 1998. Areas fished by the North Pacific fleet in 1999 changed significantly from those fished in 1998. Most of the 1999 catch was from areas off California, whereas most of the 1998 catch was from areas off Oregon and Washington. The 1998-99 U.S. catch of South Pacific albacore was 1,200 mt, a decrease from 1,800 mt in 1997-98. Areas fished in the South Pacific were about the same in 1998-99 as in 1997-98. The CPUE, in number of fish per day fished, for the North Pacific decreased significantly in 1999 to 40 fish per day from 113 fish per day in 1998. This decrease is probably related to increased fishing effort in 1999 and crowding in the fishing areas. The CPUE in the South Pacific increased to 77 fish per day in 1998-99 from 53 fish per day in 1997-98. The average size of fish in the North Pacific catch increased to 73 cm in 1999 from 68 cm in 1998 and, in the South Pacific, to 70 cm in the 1998-99 season from 67 cm in the 1997-98 season.

U.S.-Canada Albacore Tuna Treaty – An SWFSC scientist presented a summary of Pacific albacore fishery statistics at talks between the United States and Canada held in Seattle in April 2000. The report prepared by Fisheries Resources Division staff summarized U.S. and Canadian Pacific albacore troll fishery catches and effort inside and outside the Canadian and U.S. Exclusive Economic Zones, estimates of total albacore catches, and number of vessels and catch for Canadian troll vessels that landed in U.S. ports. The information is being used in discussions on continuing the U.S.-Canada Tuna Treaty that allows Canadian and U.S. vessels to fish in each nation's waters and land their albacore catches at designated west coast ports.

AFRF Activities – The American Fishermen's Research Foundation (AFRF) and the La Jolla Laboratory began a joint observer program in 2000 to learn more about the distribution and population dynamics of the North Pacific albacore stock. Two biologists were placed aboard U.S. commercial albacore troll vessels for four to six weeks at sea last summer to collect information about albacore stock structure and distribution.

The AFRF director and Fisheries Resources Division staff met last May to discuss the practicality of implementing an albacore monitoring program. One feature of the program discussed at length was the automatic logging of echosounder records from fishing boat transducers. These data would be processed to provide indices of albacore forage as well as records of deep schools of albacore. This information would be combined with records of troll catch and other environmental data to provide high-resolution maps of albacore schools and their environment. The discussion yielded several practical approaches for implementing such a data logging system on fishing boats, and the information is being evaluated by the division's Advanced Technologies Group.

La Jolla Laboratory scientists also continued to participate in AFRF board meetings during the year, to review proposed research on Pacific albacore stocks and provide technical advice on upcoming projects.

North Pacific Albacore Workshop – The 17th North Pacific Albacore Workshop was held at the National Taiwan University in Taipei, Taiwan, in December 2000. This was one in a series of ongoing workshops organized to address research issues pertaining to the albacore population of the North Pacific Ocean. The 2000 workshop reviewed information for determining status of the North Pacific albacore stock and, more importantly, established concrete plans for collaborative work among Japanese, Taiwanese, Canadian, and U.S. researchers over the next two years to improve albacore stock assessments.

SWFSC scientists presented several papers at the workshop. The authors discussed important time series (size and age distributions, indices of relative abundance) associated with the portion of the migrating albacore 'stock' in the eastern Pacific Ocean and described a modified stock-production analysis that allows meaningful management-related reference points to be evaluated.

The workshop participants tentatively agreed to an intersessional meeting in 2001, which will likely be organized as an informal session during the next meeting of the Interim Scientific Committee on Tunas and Tuna-like Species. At that session, albacore researchers will exchange data sets necessary to conduct age-structured analyses across the stock's entire (pan-Pacific) range. The 18th regular albacore workshop will be planned for late 2002 and held in La Jolla.

Port Sampling Programs Reviewed – In February 2001, staff from the Pacific States Marine Fisheries Commission, the California, Washington, and Oregon fisheries agencies, and the SWFSC met to review state sampling programs for North Pacific albacore. Reports on port sampling of the U.S. albacore troll fishery were presented by each of the state agencies, which together collected 12,295 albacore length measurements and 254 logbooks covering more than 9 million pounds of albacore landed on the U.S. west coast last year. Programs to sample albacore landings at Ilwaco, Washington, Newport, Oregon, and San Pedro, California, will continue during 2001 with NMFS funding.

III. HAWAII LARGE PELAGIC FISHERIES

Importance of Central-Western Pacific Pelagic Fisheries – Pelagic fisheries under U.S. jurisdiction in the central and western Pacific remain healthy, but the past year has been difficult for the people who rely on these fisheries. The biological stock condition of these fisheries appears to be among the best in the United States for which NOAA Fisheries is responsible. Increased attention is being paid to interactions of the longline fishery with various protected species, primarily seabirds and sea turtles.

Analysis of pelagic fisheries in the central Pacific shows no signs of overfishing, although some stocks may be near their sustainable yields. The Hawaii swordfish fishery has shown a complete recovery in CPUE (catch per 1,000 hooks) following a steep decline in 1994. Although swordfish landings have declined since 1993, this has been caused by the number of swordfish longliners that left Hawaii in 1993 and 1994 and the other swordfish boats that shifted their fishing effort to the more lucrative bigeye tuna.

Longline catch of tunas, other billfish, and associated pelagics in Hawaii grew substantially from the mid-1980s through 1999 (record level landings in weight but not in value), but landings of most species declined somewhat in 2000.

Because of longline fishery interactions with sea turtles, the Hawaii-based domestic longline fishery targeting swordfish was closed by a federal judge in the last quarter of 2000. Impacts of the court-ordered closure began to appear in the fourth quarter of 2000 and continued through the first quarter of 2001, when the entire Hawaii-based longline fishery was closed.

The small-scale, *alia* longline fishery operating out of American Samoa continues to grow dramatically with larger vessels entering the fishery.

Three western Pacific ports (Pago Pago, American Samoa; Agana, Guam; and Honolulu, Hawaii) rank in the top 10 of the most valuable U.S. fishing ports when distant-water landings are included[1]. The ex-vessel value of landings in these ports is about $350 million. U.S. canneries are the primary private sector employer in American Samoa and make a substantial contribution to operations in the Port of Guam. Local fisheries have grown substantially in American Samoa, Guam, and the Northern Mariana Islands over the past 10 years. Fisheries also have an important economic impact in Hawaii and are perhaps even more important socially and culturally.

Hawaii Longline Litigation and Pelagic Fishery EIS – In early 1999, the Center for Marine Conservation and the Turtle Island Restoration Network, represented by the Earth Justice Legal Defense Fund, sued NOAA Fisheries in federal court in Hawaii. The suit alleged inadequate protection for sea turtles related to interactions with the Hawaii-based longline fishery and inadequate preparation of environmental impact documents. The Hawaii Longline Association joined the case as defendant-intervener. Following a series of court appearances and rulings, NOAA Fisheries was required to complete an environmental impact statement (EIS) on the pelagic fisheries of the central and western Pacific regulated by the Western Pacific Fishery Management Council. The swordfish component of the Hawaii-based longline fishery was closed (except for a small number of observed sets) by the court beginning in August 2000. The entire Hawaii longline fishery was closed briefly in March 2001, but after receiving the EIS, the federal court reopened the longline fishery for tuna except during April and May. The Hawaii longline fishery for swordfish will remain closed year-round to prevent the incidental hooking, injury, and deaths of sea turtles and marine mammals. During the litigation, Honolulu Laboratory staff provided information for use in preparing the EIS and a biological opinion on the impact of the longline fishery on sea turtles and marine mammals and also were involved in reviewing the EIS in its draft and final versions.

By late March, more than 85 longline vessels were stacked up at various piers in Honolulu; several were already in dry dock. Some vessels departed to California or foreign ports. Most of the 30 or more longliners that transited to California in the late fall to follow the swordfish continue to operate from California. If owners have deregistered their vessels from their Hawaii limited entry permit, they are unaffected by the court order. Reportedly, substantial quantities of swordfish are being landed this spring in California, along with some tuna.

Prices for fresh tuna have been particularly high in Honolulu this spring. Bigeye tuna was selling for $6 to $7 per lb in the round even before the fishery closure. Supermarket prices for ahi (yellowfin tuna), where it is available, have increased to $17.99 per lb from $12.49 per lb. Seafood market newsletters have suggested that the drying up of the Hawaii fresh tuna supply will also increase prices in California and that more carbon monoxide-treated tuna can be expected to be imported. (Carbon monoxide causes tuna to retain a ruby red color but is not reported to forestall spoilage.) Market observers also are curious to see to what extent Hawaii's small boat fleet (which supplies less than 25% of the local tuna market) will be able to respond and to what extent some longline vessels experiment with other fishing strategies, for example, handline or pair trawl.

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[1]Landings by domestic and foreign purse-seine vessels in American Samoa and Guam are not reported in published statistics because of confidentiality restrictions. These estimates are based on reports from the governments of these island areas.

Tuna and Billfish Research at the Honolulu Laboratory –The mission of the Honolulu Laboratory includes providing scientific support for management decisions on fisheries for tunas, billfishes, and other highly migratory pelagic species in the Pacific. The laboratory conducts pelagic resource stock assessments and the biological and oceanographic research needed to improve stock assessment and management analysis. The laboratory's findings are provided to the Western Pacific Fishery Management Council and are major components of the council's fishery management plan for highly migratory species. The Honolulu Laboratory's research also provides support for multilateral assessment of pelagic resources and the participation of the U.S. in the emerging international arrangements for highly migratory species fishery management in the central and western Pacific and for scientific cooperation on highly migratory species in the North Pacific.

The scope of the Honolulu Laboratory's pelagics research is defined by the important issues faced by the Western Pacific Council and the international fisheries community. Besides the preeminent issues surrounding interactions between protected species and longline gear, issues include concerns about the effects of longline fisheries, including Hawaii's fishery, on shark populations, the status of swordfish targeted by Hawaii's longline fleet, and the blue marlin population important to Hawaii's recreational and charter-boat troll fleet. Of secondary concern are the status of tuna populations important to U.S. fisheries and also exploited by foreign fleets, and populations of other pelagic species about which little is known, for example, ono, opah, and mahimahi.

SWORDFISH RESEARCH

Swordfish research at the Honolulu Laboratory is guided by a comprehensive, multidisciplinary research plan developed by the laboratory's swordfish research team. This plan is used to identify, prioritize, conduct, and coordinate swordfish research at the laboratory.

Swordfish Biology – Research during the year included diet, sex identification, and age and growth studies.

Diet study – A study of the diet of central North Pacific swordfish continued as a cooperative effort between the Honolulu Laboratory and the NMFS Pacific Island Area Office longline observer program. An initial examination of stomach samples for this study is now complete. The contents of 758 stomachs were examined, identified, weighed, and measured, and the preliminary results of the study are available.

Cephalopods were the dominant food items in fish >100 cm eye-to-fork length, comprising about 60% to 70% of the diet by weight. Neon flying squid was by far the dominant prey species, at 50% to 60% of the prey weight except during the summer months. Fish were the other important general prey taxon, with crustaceans comprising a minor part of the diet by weight. Of the fish, pomfrets were the most important taxon, at about 10% to 24% of the prey by weight. The contribution of squid relative to fish in the samples changed seasonally from winter to summer. The highest percentages of squid were found in samples collected during January-March, when vessels were targeting swordfish at the Subtropical Front north of the Hawaiian Archipelago. Swordfish <100 cm eye-to-fork length ate a greater variety of food items in much greater numbers than did larger swordfish. Small fish comprised a greater proportion of the items found in the stomachs of smaller swordfish, although various small cephalopods were also important.

The next phase of the swordfish diet study will be a laboratory examination of preserved samples from the 758 stomachs examined. This phase will include verification of identifications done early in the study and back-calculation from beak sizes of squid eaten by the swordfish. Preparation of a manuscript on results from this work is planned for the coming year.

Sex identification – In the Hawaii-based pelagic longline fishery, swordfish are headed and gutted before they are landed, and the sex of individual fish is indeterminable by conventional means such as gonad size or appearance. An unconventional indicator of sex is therefore required to provide the information on the sex of individuals needed for developing age-structured stock assessment models. For the past two years, researchers at the Hawaii Institute of Marine Biology, University of Hawaii, have been developing sex markers for swordfish using specimens provided (and ground truthed) by the Honolulu Laboratory. They are using liver and gonad tissue specimens collected by NMFS observers at-sea aboard commercial longline vessels and complementary muscle tissues sampled ashore at the Honolulu fish auction by Honolulu Laboratory staff. During January-May of the past year, matched gonad-sex marker tissue specimens were collected in near-Hawaiian waters for an additional 140 individual swordfish (84 females and 56 males, ranging from 81 to 236 cm eye-to-fork length). The Honolulu Laboratory provided histological ground truth (sex identity and gonad developmental stage) for all specimens and provided these data to the University of Hawaii collaborators. Results of the sex marker analyses are pending.

Age and growth – Studies of swordfish size-at-age, based on presumed daily growth increments, were continued for smaller swordfish. The final objective of describing sex-specific size at age-1 is nearly complete, with daily growth increments estimated for about 50 young-of-the-year and yearling fish. Daily growth increments counts for young-of-the-year and yearlings are being incorporated in a final analysis of size-at-age, primarily based on counts of annuli present in cross sections of second anal fin-rays of larger (older) fish, for central North Pacific swordfish landed by the Hawaii-based pelagic longline fishery.

Preparation and reading of digital images of representative fin-ray cross sections from various regions of the North and South Pacific were largely completed (see below).

International Collaborative Research on Swordfish Age and Growth – Standardized preparation and sharing of swordfish fin-ray cross-section specimens among the five Pacific Rim laboratories which either have aged or are in the process of ageing Pacific swordfish using these hard parts have been completed. These laboratories include the NOAA Fisheries Honolulu Laboratory; National Taiwan University; National Research Institute of Far Seas Fisheries, Japan; Centro de Investigacion Cientifica y de Educacion Superior de Ensenada, Mexico; and Instituto de Fomento Pesquero, Chile. During the past year, 20 representative fin-ray specimens (from fish of all sizes, both sexes, collected in all seasons) were prepared at the Honolulu Laboratory and were prepared at and received from each of the four other laboratories, using swordfish from the respective fisheries. Standard digitized images were prepared by Honolulu Laboratory staff for all 100 specimens and digital copies were distributed to each of the laboratories for ageing. Age readings have been received from the National Research Institute of Far Seas Fisheries and Instituto de Fomento Pesquero thus far. The Honolulu Laboratory has evaluated within- and among-reader ageing error using in-house age estimates. After all laboratories have completed their readings for the entire specimen series, results will be exchanged, compared, and discussed by e-mail.

The specimen exchange is needed to distinguish differences in ageing protocols from possible regional variations in the growth rates of swordfish caught by various longline fleets in the North and South Pacific. The ultimate objective is to build consensus among laboratories to improve the accuracy as well as the precision of age-length and growth estimates for Pacific swordfish.

Swordfish Oceanographic Research – A fifth in a series of annual oceanographic cruises was conducted through the North Pacific Subtropical Frontal Zone region in efforts to characterize the pelagic environment frequented by the Hawaii-based swordfish longline fishing fleet. The survey, occupying a 630 nmi continuous stretch of ocean along 158°W between 23°N and 33°30'N, was mapped with conductivity-temperature-depth casts. Information furnished by the annual hydrographic series and concurrent satellite remote sensing data have elucidated structural patterns and coupling of the physics and the biology associated with key individual fronts, enabling recharacterization of the winter-spring North Pacific Subtropical Frontal Zone and offering new insight into the seasonal variability of the phytoplankton dynamics in the subtropical North Pacific.

On synoptic time scales, geographic positioning of the fronts may be systematically identified through surface outcropping of diagnostic thermohaline isopleths and is therefore readily discerned both from shipboard surveys and by spaceborne sensors. The Subtropical Front during winter-spring can be characterized by the surface expression of the 34.8 isohaline and the 17°C isotherm within the frontal gradient. Climatologically located at 32° to 34°N, the Subtropical Front biologically marks the transition from low chloropigment (chlorophyll + phaeopigments), nutrient depleted surface waters to the south to a more productive regime to the north. To the south, the 20°C and 35.0 surface isotherm and isohaline, respectively, are characteristically embedded in the thermohaline gradients associated with the South Subtropical Front. A sharp increase in depth-integrated chloropigment is also observed at the South Subtropical Front and is ascribed to an increase in the concentration and thickness of the subsurface chloropigment maximum (prompted by the shoaling of the nutricline with the thermocline structure into the euphotic zone. These findings are described in a paper titled "An oceanographic characterization of the swordfish fishing grounds in the subtropical north Pacific" submitted for publication in the journal Fisheries Oceanography.

Studies of Larval Swordfish and Other Billfish Larvae – Two additional research cruises sampling swordfish larvae off the Kona coast of the Island of Hawaii were conducted from the NOAA ship *Townsend Cromwell* in May and July 2000. Sampling was conducted using a 6-ft Issacs-Kidd trawl that was towed for one hour along the surface. These tows yielded 31 swordfish larvae (primarily 2 or 3 cm eye-to-fork length) during the May cruise but none during the July cruise. Larval istiophorids also were captured during these cruises, consisting of 57 and 12 larvae collected in May and July, respectively. On the July cruise, dip-netting from a small boat yielded two larger swordfish (~20 cm eye-to-fork length) collected during the day from within surface slicks. Although collected in good condition, these two specimens survived only 1 or 2 days in captivity.

In a related study, 1,062 mahimahi stomachs were examined for the presence of young swordfish. These stomachs were sampled daily during June-October 2000 at a cooperating wholesale-retail fish market in Honolulu. This survey yielded 24 young swordfish specimens (10 to 30 cm eye-to-fork length) and 11 young unidentified istiophorids. In the previous year, 44 swordfish specimens were obtained from the examination of 1,470 mahimahi stomachs. These swordfish specimens are being used to fill in gaps in young swordfish age-length plots as well as

provide tissue samples for current genetics-based swordfish stock structure investigations. Additional tissue samples from young swordfish for stock structure studies were sent to Stanford University and Instituto de Fomento Pesquero in Chile.

A collaborative project between the La Jolla and Honolulu Laboratories was undertaken to identify 131 young istiophorids (collected during 1995-99 off Kona, Hawaii, and in 1999 from mahimahi stomachs) based on molecular techniques. The fish genetics research group at the La Jolla Laboratory employed a polymerase chain reaction-based restriction fragment length polymorphism technique that provides the ability to distinguish between Indo-Pacific billfishes. Results indicate that most (75%) of these unidentified young istiophorids were shortbill spearfish, 10% were blue marlin, and 15% remained unidentified. The researchers currently are working on a plan to test whether this technique can be conducted shipboard while at sea. If successful, this new ecological tool would allow the researchers to adapt their sampling strategy, particularly if suspected egg stages of swordfish or other billfish can be identified while at sea.

Swordfish Cooperative Tagging With Industry – A tagging program on swordfish continues to investigate long-range movements of swordfish and to help validate growth rate estimates based on hard part ageing studies. In addition to swordfish tagged during research cruises, about 60 swordfish per year are tagged and released by U.S. swordfish longline fishermen. Out of about 600 swordfish tagged and released, so far six have been recovered. The results suggest some long-range movements towards the American west coast from the Hawaii area, but most of the tags have been released and recovered in the fishing grounds north of Hawaii. Experienced swordfish longline fishermen also have been contracted to tag and release fish of commercially valuable sizes. Several dozen swordfish have been tagged via contract, with one recovery so far. The contract tag was recovered from a fish after 1.5 years at large, about 250 miles from the point of release in the fishing area north of Hawaii.

RESEARCH ON TUNA AND ASSOCIATED SPECIES

Bigeye Tuna Oceanographic Research – Honolulu Laboratory scientists continue to examine the role of oceanography in aggregation and vulnerability of bigeye tuna through satellite, moored, and shipboard platforms and time series. After a year-long deployment, a moored oceanographic array (BIGEYE-1) was retrieved in December 2000. The data were downloaded and are currently being analyzed. The mooring was redeployed (BIGEYE-2) southwest of Niihau Island in 4,630 m of water. These moorings provide a time series of the vertical structure of ocean temperature and current velocities, as well as conductivity and dissolved oxygen concentration at discrete depths. BIGEYE-2 is expected to be retrieved in December 2001.

Shipboard surveys conducted in November 1999 and 2000 targeted Hawaiian wind-generated eddies to assess mesoscale variability on the vertical water column structure and dynamics. The cyclonic features were observed to induce localized upwelling and upward nutrient flux resulting in enhanced chlorophyll standing stock and increased primary productivity. Strong ocean currents (and vertical shear) characterized the flow at the eddy periphery with velocities as high as 80 to 100 cm/s^{-1} (~2 knots). A third survey in April 2000 used closely spaced (about 10 km) conductivity-temperature-depth casts along the TOPEX satellite crossover path through the BIGEYE mooring site to establish the spatial representativeness of the mooring observations.

Archival Tagging of Bigeye Tuna – To understand harvest impacts and interactions among fisheries for populations of tuna and billfish across the Pacific, information is needed on migration patterns and environmental factors influencing distribution and vulnerability to specific fishing gears. Archival tags provide a powerful new tool for acquiring these data. The Honolulu Laboratory is, therefore, conducting an archival tagging project on bigeye tuna and swordfish in collaboration with the Pelagic Fisheries Research Program of the University of Hawaii's Joint Institute for Marine and Atmospheric Research (JIMAR) and the Commonwealth Scientific and Industrial Research Organization of Australia. Archival tag deployments in the Hawaiian Islands have focused on discerning the movement patterns of bigeye tuna associated with islands, seamounts, and fish aggregating buoys.

Since April 1998, 77 archival tags have been deployed during research cruises aboard the NOAA ship *Townsend Cromwell*. Tags were deployed on fish ranging from 51.9 cm fork length (2.8 kg) to 131 cm fork length (44.5 kg). All fish were captured and released within approximately 300 nmi (556 km) of the main Hawaiian Islands and the majority (≈80%) were directly associated with either seamounts or fish aggregating buoys. Tags were implanted into either the dorsal musculature or the peritoneal cavity of the fish.

As of March 2001, 12 fish have been recaptured and data have been successfully downloaded from 10 tags (representing 570 days at liberty), from which 474 days of retrievable geolocation, depth, and internal and external temperature data were obtained. The fish were at liberty from several weeks to up to 9 months. The deepest dive recorded was 817 m, the coldest temperature visited was 4.7°C, and the minimum oxygen level reached was estimated to be >1 ml/l^{-1}. The greatest difference between ambient and internal body temperature was 19.7°C. Average daytime depths and ambient water temperatures were linearly related to fish size (larger fish descended deeper and into colder water), whereas average nighttime depths were not. Five out of 10 fish exhibited significant correlations (from 25% to 52%) between lunar phase and average daytime depth distributions, and 4 out of 10 fish exhibited significant correlations (from 30% to 74%) between lunar illumination and average nighttime depth distribution. These observations confirmed and explained a previously observed correlation between catch rates of bigeye tuna on longline gear and moon phase. When apparently associated with seamounts or buoys, fish stayed in the mixed layer both night and day, whereas when not associated with these structures, bigeye tuna showed characteristic "W" diving patterns during the day (that is, descending to depths below the thermocline and then regularly returning to the mixed layer to ostensibly warm muscles or to repay an oxygen debt).

North Pacific Blue Shark Stock Assessment – The Honolulu Laboratory is developing a Multifan-CL model of blue shark in the North Pacific in collaboration with Japan's National Research Institute of Far Seas Fisheries. In addition to life history information, the model incorporates catch, effort, and size-composition data collected during the period 1971 through 1998 from longline and high-seas driftnet fisheries in the North Pacific. Both commercial fishery statistics and data from research and fishery training vessels are employed. Catch and effort statistics from the United States and Japan and effort data from Taiwan and Republic of Korea fisheries are incorporated.

The results to date indicate that current levels of fishing effort in the North Pacific are having a mild impact at most on the blue shark population. Under the least optimistic scenarios, maximum sustainable yield is estimated to be approximately twice the current levels of blue shark catch,

and the fishing effort necessary to achieve maximum sustainable yield is at least twice the current levels of fishing effort in the North Pacific longline fleets.

Pacific Blue Marlin Stock Assessment – Researchers from Japan's National Research Institute of Far Seas Fisheries, the Inter-American Tropical Tuna Commission (IATTC), and the Honolulu Laboratory are collaborating to develop a Multifan-CL model of Pacific blue marlin. Pacific-wide longline and purse-seine catch and standardized effort data received from the IATTC are currently awaiting processing to a format suitable for input to Multifan-CL.

RESEARCH TO MITIGATE LONGLINE FISHERY INTERACTIONS WITH PROTECTED SPECIES

Incidental Take and Mortality of Sea Turtles – The number of sea turtles taken by the Hawaii-based longline fishery during 1999 was estimated using NMFS observer and longline logbook data for 1994-98. Takes for earlier years also were reestimated. As in previous years, the number of takes recorded by the observers on monitored longline sets was assumed to be correct. Takes on unobserved longline sets were estimated by applying statistical models of the take per set to predictor variables reported in the logbook data for those sets. A take prediction model was developed for each turtle species. Total takes for the year were computed by summing results over all sets, observed and unobserved.

Estimates of total kill by species were computed by multiplying the estimates of total take by estimates of the mean kill per take. The latter were derived from observer information on the type of interaction with the longline gear, condition of the turtle, and other assumptions.

Take-per-set models were developed by analyzing all observer and logbook data collected during 1994-99, using modeling and estimation methods similar to those used in a previous study. Details of the sea turtle take estimation were published in SWFSC Administrative Report H-00-06.

Incidental Take and Mortality of Albatrosses – The number of black-footed albatross and Laysan albatross taken by the Hawaii-based longline fishery during 1999 were estimated and takes for 1994-99 were reestimated. The estimates were derived from NMFS observer data and longline logbook statistics accumulated from 1994 through 1999. Details of the analysis are described in SWFSC Administrative Report H-01-03.

The analytical approach used in this study was very similar to the one used to estimate sea turtle takes. A prediction model was developed for each albatross species and related the number of takes documented by an observer to ancillary variables recorded in longline logbooks or derived from such variables. The model was then used to predict the number of albatrosses taken on each unobserved trip on the basis of the predictor variables recorded in the logbooks for those trips. The total annual take for the fleet was estimated by adding the sum of predicted takes for the unobserved trips to the sum of recorded takes for the observed trips.

After exploring several alternative statistical models for take estimation, a negative binomial generalized linear model was adopted. Variables well represented in the logbooks and transformations of them were considered as candidate predictors. A bootstrapping procedure was used to construct approximate "prediction intervals" for take. The bootstrap analysis also produced estimates of the estimation bias; the latter was used to adjust the point estimates.

Estimates of takes for the years 1994-98 differ from values computed and reported previously. The revised estimates are based on a larger accumulation of observer statistics and different prediction models.

Evaluation of Time-Area Closures to Reduce Turtle Takes – Time and area closures and gear modifications in the Hawaii-based longline fishery were examined using computer simulation to identify management scenarios that would effectively reduce interactions with sea turtles while minimizing hardship to longline fishermen. Generalized additive models and an approach termed "stratification/expansion" were used to construct a database of predicted turtle take. Data gathered by NMFS observers and high-resolution environmental data merged with the fishery data were used in both approaches. Computer simulation was used to assess the impact of seasonal closures and/or spatial closures over a systematic grid of 361,194 possible closure scenarios. A fishery response based on monthly patterns of fishing activity by trip type was used to predict effort reallocation subsequent to management action. Immediate impacts to the fishery were measured by predicting the fraction of the fleet displaced spatially or temporally by the proposed management action. Financial impacts were also estimated using predicted catch rates of the displaced fishing effort and recent market revenue data. "Efficient frontier" analysis was used to determine the efficacy of proposed management scenarios.

Leatherback sea turtles were of primary concern due to their endangered status. Because of their widespread pattern of take (primarily in space but also in time), it was difficult to determine an optimal management scenario for this species; however, the January through June season, particularly April-May, was a potential target for a seasonal closure. Swordfish-style sets (shallow gear configuration) were also determined to be detrimental for all species of sea turtles.

The analysis of the effects of alternative time-area closures upon fishing effort, fishing revenues, fishery catches, and incidental takes of sea turtles was used in developing proposed time-area closure schemes for the Hawaii-based longline fishery and in recommendations for the EIS and biological opinion for the fishery.

Sea Turtle Population Dynamics – Researchers from Mexico's Instituto Nacional de la Pesca and the Honolulu Laboratory are collaborating in a study of the Mexican population of Pacific leatherback sea turtles. The population has declined greatly over the last two decades due to egg poaching, incidental mortality in fisheries, and other factors. The researchers are analyzing data collected from turtle nesting beach surveys and are constructing a simulation model of leatherback population dynamics using TURTSIM, a sea turtle simulation code developed at the Honolulu Laboratory. The simulator incorporates details of leatherback biology and human-caused mortality from user-specified sources and enables studies of the relative impacts of different mortality sources and the effectiveness of recovery strategies. A similar collaboration to develop a model of Japanese loggerhead population dynamics is underway between the Honolulu Laboratory and colleagues in Japan, including the Japan Sea Turtle Association.

Working Groups on Reducing Turtle Bycatch in Longline Fisheries – A Working Group on Reducing Turtle Bycatch in the Hawaii Longline Fishery met in September 2000 in Hawaii. Participants included representatives of the longline fishing industry, conservation groups, and fishery scientists. The objectives of the meeting were to review possibilities for reducing sea turtle bycatch, make recommendations for research, and provide guidance regarding longline fishery regulations in Hawaii, the United States, and internationally. Presentations included a review of Honolulu Laboratory research programs to investigate turtle post-hooking survival and

oceanic habitat, study sensory cues that attract or deter turtles from fishing gear, and identify and test modifications to fishing gear and tactics that reduce turtle bycatch. Technological options for changing fishing gear and practice were discussed at length. Promising measures discussed included moving fishing operations when turtles are encountered, eliminating branch lines adjacent to float lines, dyeing squid bait blue using food coloring, replacing J hooks with circle hooks, dehooking systems, and enhanced training in turtle handling and resuscitation.

A second meeting of the working group was held in San Diego, California, during January 2001. Presentations were made on turtle research activities underway at the Honolulu Laboratory and on other ongoing research related to reducing turtle-longline interactions. Extensive discussions of draft biological opinions, environmental impact statements, and development of mechanisms to allow fishermen to participate in sea turtle research programs followed the presentations.

A similar meeting organized by the NMFS Highly Migratory Species Division was held in Silver Spring, Maryland, in January. The meeting considered potential gear modifications and configurations to reduce the take and discard mortality of sea turtles incidentally caught in the Atlantic pelagic longline fishery. In follow-up meetings, the Honolulu Laboratory and the NMFS Southeast Fisheries Science Center have been working on research plans to test turtle bycatch reduction strategies in an experimental fishery in the Grand Banks.

Research to Reduce Sea Turtle Bycatch on Longline Gear – The Honolulu Laboratory plans to continue working cooperatively with the Hawaii-based and the Mexico-based longline fishing industries to reduce sea turtle bycatch and post-hooking mortality of sea turtle takes. A suite of voluntary fishing gear and tactical modifications was tested by Hawaii-based longliners in January-March using fishery observers to record the results. A comprehensive analysis of previously unexplored details on the set, soak, and haul back times of each longline hook that caught sea turtles and analysis of other aspects of fishing gear and practice is also under way.

The Honolulu Laboratory is proceeding with an application for a scientific permit under the Endangered Species Act to conduct fishing experiments to reduce the bycatch and mortality of sea turtles on longline gear. The most ambitious experiments proposed in the application are premised on a staged reduction of loggerhead and leatherback sea turtle takes across the Hawaii-based longline fishery, from 25% in the first year, to 50% in the second, to 75% in the third and final year of the experiment. Alternatively, experiments could be conducted with fewer turtle takes over a longer time period. The research would continue an experiment begun with volunteer Hawaii swordfish longliners in January-March using blue-dyed bait, removing branch lines near floats, and moving the fishing vessel following a turtle interaction. Additional research would include "stealth" fishing gear (counter-shaded floats, dark main line, and dark-colored branch line snaps), deep daytime versus shallow nighttime fishing for swordfish, hook timers to measure the time and depth of turtle captures, and different hook designs. The proposed experiments would have 100% observer coverage, and incidental takes of sea turtles would be reported to NMFS on a real-time basis using the satellite vessel monitoring system. NMFS would cease the experiments if the established incidental take levels were being exceeded or were likely to be exceeded.

Laboratory experiments at Kewalo Research Facility also have been initiated to test sea turtle reactions to blue-dyed bait, artificial bait, and other sensory stimuli. The objective of the experiments is to identify bait or other components of fishing operations that can be made less attractive to sea turtles. The test involves subadult green sea turtles held in tanks at the Kewalo

facility. All the turtles are slightly to moderately affected by fibropapillomatosis disease. Preliminary results are encouraging, as the project has identified blue-dyed bait is repellent, at least initially, to green sea turtles. Further sensory physiology experiments are under way.

Efforts also have been increased to electronically tag more turtles caught in the fisheries and at nesting beaches, to relate their movements to environmental characteristics that define high-seas habitats and to correlate physiological measures of condition at release with post-release survival. In related work, behavioral differences between lightly and deeply hooked pelagic turtles incidentally caught in the Hawaii-based longline fishery were evaluated using surface counter data collected by satellite transmitters. Percent of time on the surface was calculated for 18 sea turtles: 9 deeply hooked (7 loggerhead and 2 olive ridley) and 9 lightly hooked (5 loggerhead, 3 olive ridley, and 1 green). There was no significant difference ($P>0.05$) in the calculated percent surface time between the nine deeply hooked turtles (mean = 34.1 +/- 14.7% time on surface) and the nine lightly hooked turtles (mean = 30.0 +/- 14.5% time on surface).

FISHERY MONITORING AND ECONOMICS

Preliminary[2] Summary of the Year 2000 Western Pacific Longline Fishery – Preliminary figures show that the 2000 Hawaii longline season had smaller landings but greater value than in 1998 and 1999. Total landings (all species combined) in the year 2000 were 24 million lb ($50 million ex-vessel revenue) compared to 28.3 million lb ($47.3 million ex-vessel revenue) in 1999[3]. The record year for Hawaii longline landings was 1998 (28.8 million lb), and the record year for ex-vessel revenue ($53.3 million) was at the height of the swordfish fishery in 1993. In terms of vessel participation and activity, the year 2000 was quite similar to 1999 except for swordfish-targeted trips: 125 vessels were active in 2000, taking 1,100 trips with 12,900 sets and 20.3 million hooks (a record due to the larger number of hooks per set from tuna-targeted sets).

In 2000, swordfish landings in Hawaii were 6.5 million lb, down only slightly from 1999 and 1998, indicating the year 2000 had quite high availability of swordfish despite diminished directed effort. In addition, more than 30 longline vessels targeting swordfish operated out of California at some time during the year and most remained there throughout the spring of 2001. Their landings are not included in the Hawaii figures.

Bigeye tuna landings were 5.8 million lb, down slightly from 1999 landings. Yellowfin tuna landings were 2.5 million lb, up dramatically from 1999 landings and almost the same as 1997 landings (the peak); yellowfin tuna landings show substantial interannual variation around an apparently stable trend. Albacore landings were 2.0 million lb, the lowest in five years. Blue shark landings were down dramatically because of State of Hawaii and federal restrictions on landing shark fins. More information on 2000 landings will be published later this year in the

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[2] Preliminary figures from complete logbook data on numbers of each species landed but incomplete information on average weights and prices.

[3] Most of the impact of the federal court rulings was felt by the swordfish component of the fishery in the fourth quarter of 2000 (which is normally a low quarter for that sector) and by the tuna component of the fishery in the first quarter of 2001.

Honolulu Laboratory's annual report on the fishery and online at the Fishery Monitoring Economics Program Web site (http://www.nmfs.hawaii.edu/fmpi/fmep/longline_n.htm).

Longline Reports From Vessels Landing in California – Honolulu Laboratory staff have compiled data from four different logbook formats filed by longline fishermen off-loading in California since 1995 (Table 1). The data should be viewed as preliminary, but they appear to offer a useful picture of longline operations out of California. These data sources include State of California longline logbooks from 1995-2000, NMFS western Pacific logbooks from longline vessels off-loading in California from 1991-2000, NMFS pre-high-seas logbooks (205 sets) from vessels operating out of California in 1998, and NMFS high-seas logbooks from similar vessels in 1999 and 2000 (6 trips total)[4].

Table 1. California longline report, 1995-99

Preliminary data compiled from State of California, NMFS western Pacific, and NMFS high-seas logbooks for longline vessels off-loading in California. Numbers of vessels, trips, sets, and pelagic management unit species (PMUS).

	1994	1995	1996	1997	1998	1999
Vessels	2	14	20	29	20	48
Trips	5	29	59	51	40	91
Sets	42	313	659	609	477	1,327
Swordfish	228	1,246	6,333	9,248	4,859	14,880
Albacore	3	448	1,192	208	1,182	2,409
Bigeye	7	444	2,042	2,171	1,718	3,322
Bluefin	0	39	41	55	926	1,119
Yellowfin	2	210	147	76	76	56
Total Other PMUS	254	523	2,545	262	225	3,222

Longline Fishery Research – A JIMAR associate researcher has completed several manuscripts comparing logbook, observer, and landings information from the Hawaii-based longline fishery to find factors affecting logbook reporting reliability. In brief, the researcher has found high levels of concordance for target species but somewhat less for nontarget species and even less for protected species interactions. The research has also been useful in identifying factors which can predict catch and interaction rates. Two publications are forthcoming.

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[4]Late in 2000 the number of high-seas logs received by the Honolulu Laboratory increased dramatically as at least 30 swordfish-targeting longline vessels operated out of California.

Summary of the Year 2000 American Samoa Longline Fishery – The Honolulu Laboratory's Western Pacific Fishery Information Network program has set up a cooperative data compilation and reporting system with the fisheries office in American Samoa to handle federal logbooks for longline vessels fishing there. A complete report on longline data for the year 2000 will be available online later in the year (http://www.nmfs.hawaii.edu/fmpi/fmep/samoa_n.htm).

Fishing effort was at a record high for this relatively new domestic fishery (1996 to present): 34 vessels operated in 2000, making 2,700 sets totaling 1.3 million hooks. Catches of albacore, the target species, were up dramatically, at more than 30,000 fish, with CPUE at 24.4 fish per 1,000 hooks. Skipjack, yellowfin, and bigeye tuna catches reached record highs in 2000.

Economic Research in Hawaii's Pelagic Fisheries – NMFS economists in Hawaii were active in late 1999 and throughout 2000 in estimating the impact of various proposed and court-ordered restrictions on Hawaii-based longline fishery. Much of this work benefitted from work sponsored by the JIMAR Pelagic Fisheries Research Program and University of Hawaii and other economists working with this program. The final "preferred alternative" proposed in the EIS for the central and western Pacific pelagic fisheries managed by the Western Pacific Fishery Management Council involved a complete prohibition of shallow-set (swordfish target) fishing by longline vessels operating with Hawaii limited entry permits and a time-area closure to deep-set (tuna target) longlining in a broad area south of Hawaii during April and May. Using a time-area analysis model, the direct economic effect of this closure was estimated to be between $-4.3 and $-17.1 million in ex-vessel revenue depending on how many swordfish vessels switched to tuna-style longline fishing. In addition to these direct ex-vessel effects, there are also losses to vessel owners from the uncertainty and opportunity costs of being required to change their fishing practices, losses to seafood consumers from increases in the price of fresh seafood during the closed season, and fishing supply, inter-industry, and income effects throughout Hawaii's economy. The latter are expected to add $6 to $24 million in economic losses to Hawaii depending on vessel switching behavior. Some of these costs may be made up in other locations (for example, California or overseas) to the extent that longline vessels are able to operate elsewhere.

A cooperating JIMAR fisheries researcher has completed fielding on a Hawaii charter patron study. The work consists of a follow-up and comparison to earlier fielding by a previous JIMAR researcher on this project. The project, started in early 2000, consists of distributing surveys that ask charter patrons about their fishing experiences, the fishing-related expenses of their trips to Hawaii, and their motivations to visit Hawaii and to go charter fishing. Packets of surveys were distributed to charter captains at various ports on Oahu, Maui, Hawaii, and Kauai for subsequent distribution to their patrons. In order to boost the return rates, researchers have conducted dockside interviews and distributed surveys to charter patrons returning from fishing trips. Patrons who returned the surveys to the researchers received prizes. To date, more than 250 surveys have been returned using the indirect methodology of relying on charter boat captains to distribute the surveys, along with almost 50 returns from the direct solicitation method. Preliminary evidence suggests much higher return rates with the direct solicitation method with potentially less bias in the attitudes of fishing patrons. A report on this secondary fielding is expected in time for the Lake Arrowhead Tuna Conference.

Another cooperating JIMAR economics researcher has examined a number of fishing capacity issues in the Hawaii-based longline fishery and has begun focusing on modification of a model that will allow a more flexible spatial and temporal dimension to the reallocation of fishing fleets

due to time-area closures. A paper on this study titled "Decision support model for fisheries management in Hawaii: a multilevel and multiobjective programming approach" was published in the North American Journal of Fisheries Management (Pan et al. 2001).

IV. EASTERN TROPICAL PACIFIC TUNA FISHERIES

The International Dolphin Conservation Program Act (IDCPA) requires NOAA Fisheries to conduct scientific research and make a determination of whether the intentional deployment on or encirclement of dolphins with purse-seine nets is having a significant adverse impact on any depleted dolphin stock in the eastern tropical Pacific Ocean (ETP). To that end, the La Jolla Laboratory is continuing research to collect data that will be used to make a final determination in 2002.

IDCPA Research – The third year of mandated research surveys to estimate the current abundance of dolphin stocks affected by the tuna purse-seine fishery in the ETP was completed in December 2000. A pilot necropsy program to collect skin samples from dolphins killed during fishing operations continued during the year, along with an investigation of molecular genetics techniques to identify molecular-level effects of fishery-induced stress in dolphins and to determine cow/calf relatedness in mortalities from single sets. Work continued to complete estimates of abundance for all species of marine mammals sighted on the research cruises, as did work on development of a decision analysis framework and population assessment model to quantify the likelihood that depleted stocks of ETP dolphins are or are not recovering as expected since a dramatic decrease in reported mortality beginning in 1992.

The NOAA ships *David Starr Jordan* and *McArthur* were platforms for the dolphin population abundance research surveys conducted in 2000. The surveys consisted of visual observations of more than 31,000 nmi of vessel tracklines in the ETP. A total of 1,393 marine mammal sightings were made, and scientists also recorded sightings of seabirds and sea turtles. Helicopter operations were conducted in order to photograph dolphin schools. These photographs are used to calibrate observer estimates of marine mammal school size, for analysis of cetacean lengths and for studies of pinniped and seabird colonies. Photographs of cetaceans were also taken from the research vessel and from small boats to use in verifying stock identity and to document geographic variation. Acoustic recordings of cetaceans were made by deploying sonobuoys during sightings. Cetaceans tissue samples were collected for genetic analysis as well. Daily sampling of flying fish and other surface organisms was also conducted. Micronekton biomass was sampled between 0 and 500 m depth using active acoustics. Concurrent with these activities oceanographic data were collected several times a day.

Although the primary aim of these research surveys is to determine abundance of depleted dolphin stocks, this variety of ancillary research projects was included to aid in interpreting the results of the abundance estimation. In order to better evaluate the consistency between previous and current estimates of abundance, this ancillary research was designed to help determine if environmental conditions have changed substantially since previous abundance estimates were produced.

The necropsy program was designed to collect fresh tissue samples from dolphins killed during routine fishing operations. Under the current pilot program, several technicians have been

trained to perform these procedures. To date, technicians have collected samples from 19 specimens; the samples will be sent to various laboratories for analysis.

The first of two molecular genetics projects is investigating the ability to assess stress levels from dolphin skin cells. A large historical data bank of skin samples from the fishery is available for analysis. Also, samples for these studies continue to be collected from both fishery-affected animals (biopsy samples collected from fishing vessels of animals in purse-seine nets) and fishery-unaffected animals (biopsy samples collected from research vessels). A second genetics project estimates the potential effects of tuna fishery operations on cow/calf separation and differential mortality. Results of this study have been submitted for publication and will be included in a report on NMFS research under the IDCPA to be published in 2002.

In 1999, NOAA Fisheries made an initial Report to Congress containing details of the dolphin abundance survey and stress studies completed in 1998. Based on this report, the Department of Commerce made an initial finding, as required by the IDCPA, that there was insufficient evidence that chase and encirclement by tuna purse-seine fishing is having a significant adverse impact on depleted dolphin stocks (eastern spinner, northeastern offshore spotted, and coastal spotted) in the ETP. As a result of this finding, the U.S. "dolphin-safe" labeling standard will be changed to allow the use of the "dolphin-safe" label on tuna caught in the presence of dolphins if no dolphins were observed killed or seriously injured during the set in which the tuna was harvested.

The Report to Congress and other IDCPA research results are available on the SWFSC Internet site (http://swfsc.nmfs.noaa.gov/IDCPA/IDPCAfront.html). Information about the Commerce Department's decision and interim final rule implementing the provisions of the IDCPA can be found on the NOAA Fisheries Office of Protected Species Web site (http://www.nmfs.noaa.gov/prot_res/PR2/Tuna_Dolphin/tunadolphin.html).

Dolphin Abundance Estimates Reviewed – In October 2001, SWFSC scientists participated in an IATTC review of the 1998 and 1999 estimates of abundance for dolphins affected by the ETP yellowfin tuna fishery. The review also was attended by scientists from IATTC member and observer countries and invited scientists with expertise in estimating population abundance using line transects and in the oceanography of the ETP. The participants discussed the NMFS survey design and results, dolphin stock boundaries and distributions, differences between the 1998 and 1999 surveys, oceanography related to dolphin distributions, a potential regime shift in the eastern Pacific Ocean, inter-annual variability in survey results and oceanography, and other factors potentially affecting survey variability. The review group supported the SWFSC's estimation methodology and made suggestions for improvements.

Decision Framework Planning – An IDCPA planning meeting took place at the La Jolla Laboratory in March 2001. The purpose of the meeting was to continue development of a decision framework for arriving at a determination of whether or not chase and capture by the tuna purse-seine fishery is having a significant adverse impact on depleted ETP dolphin stocks. A final Commerce Department determination on this question is due next year. The planning meeting involved a number of senior managers and scientists from NOAA Fisheries headquarters, the Southwest Region, and the Alaska and Southwest Fisheries Science Centers. The participants evaluated means to formally consider both the scientific and policy aspects of the decision and distinguished the separate roles of scientists and policy officials in the process. The resulting plan will become a draft notice for publication in the Federal Register.

V. SHARK RESEARCH

Juvenile Shark Abundance Survey – The California-based driftnet fishery catches a significant number of juvenile thresher, shortfin mako, and blue sharks. These transboundary fish stocks are also under increased fishing pressure from commercial fishing off northern Baja California, Mexico. Currently, there are no stock assessments for these species, although they will soon be managed under a fishery management plan now being developed by the Pacific Fishery Management Council.

Since 1994, the Fisheries Resources Division has conducted a survey to index shortfin mako shark abundance in the Southern California Bight. This survey provides the only fishery-independent assessment of abundance for juvenile mako shark off the west coast. In 2000, the survey was expanded to examine changes in the southern California thresher shark population, which has specialized habitat, movement, and feeding preferences.

Biologists aboard the NOAA ship *David Starr Jordan* completed 55 longline sampling stations during the June 2000 shark abundance survey. Of those stations, 21 were designed to sample common thresher sharks and 34 sampled shortfin mako and blue sharks. Generally, CPUE for mako and thresher sharks (average 0.5 sharks per 100 hook hours) was below previous levels, while CPUE for blue sharks was higher than seen in previous years. In total, 51 mako sharks, 34 thresher sharks, and 1,003 blue sharks were captured and sampled during the cruise. Forty mako sharks and 31 thresher sharks were tagged and injected with oxytetracycline for ongoing age and growth studies. Blue sharks (292) were tagged for movement and migration studies. In addition, blood was drawn from 24 thresher sharks, 38 mako sharks, and 68 blue sharks for studies on condition at capture and post-release survival of tagged fish. A preliminary assay of blood chemistry indicates very high catecholamines and lactate levels in all three species when compared to resting, captive sharks, but the recapture rate to date (nearly 4%) indicates these sharks can tolerate the observed elevated levels.

A juvenile shark abundance survey planned for June 2001 will include trend analysis, abundance indexing, and a series of ancillary experiments to provide information on shark reproductive biology, age and growth, movement patterns, and post-release survival.

Thresher Shark Diet Study – Results of an investigation into the diet of common thresher shark were presented at the CalCOFI Conference in October 2000. The study examined stomach samples collected from thresher shark taken in the California and Oregon drift gillnet fishery to determine feeding habits, including possible differences resulting from the predator's size, the season, and the geographic area.

The Pacific Fishery Management Council recently added the common thresher shark to species addressed by a fishery management plan for Pacific highly migratory species, now in development. The council's plan development team needs biological information on the feeding ecology and essential fish habitat of common thresher shark in order to assess harvest impacts. No formal feeding study has been undertaken for this species, but anecdotal information suggests that the species feeds almost exclusively on northern anchovy off the U.S. west coast.

The study indicates a more varied diet than expected and reflects possible differences in food preferences north and south of Point Conception, California. Northern anchovy was the preferred prey in southern California, while Pacific hake was preferred in the north. A variety of

other food items representing 18 other taxa was consumed. The results confirm the importance of anchovy in the diet of thresher shark but suggest a broader feeding niche than previously thought.

Coastal Shark and Swordfish Habitat Study – The Fisheries Resources Division has begun a study of the habitat of swordfish and sharks in coastal waters off California. The study is investigating how swordfish, sharks, and bycatch species are distributed in relation to their physical environment and in response to climate conditions and changes.

For the study, federal observers in the coastal gillnet fishery have begun measuring ocean thermal structure. Temperature and depth recordings were made on 25 gillnet sets, both before and after net deployment, during the 1999-2000 fishing season. Researchers used this data to create temperature profiles for each set and entered the data into a database for comparison with fishing logbook data. Because the small number of sets for which recordings were made is insufficient for a meaningful analysis of how ocean thermal structure relates to fishing results, plans are being made to deploy the instruments on more trips during the next fishing season.

Fluctuations in fish distribution and fish populations generally are thought to relate closely to changes in the physical environment. This sampling program should help to improve understanding of the relationship between pelagic sharks and swordfish and the physical habitat they occupy.

VI. BILLFISH INVESTIGATIONS

The SWFSC's billfish research programs provide information for the conservation and management of billfish resources in the Pacific. These programs--the Billfish Newsletter, the International Billfish Angling Survey, the Billfish Tagging Program, and the Pacific Federal-Angler Affiliation for Billfish--all rely on continuing cooperation from billfish anglers, sportfishing clubs, commercial fishers, and agencies affiliated with the SWFSC.

The International Billfish Angler Survey – The survey now provides a 32-year time series of angler catch rates for billfish and swordfish in key locations throughout the Pacific. The information collected through this survey is used to estimate recreational fishing effort for marlin and swordfish and measure changes in angler catch rates in different areas of the Pacific. This is important information for billfish researchers, because changes in angler catch rates may indicate changes in billfish stock size, environmental conditions, or local depletion by a fishery.

In 2000, 458 billfish anglers reported catching 4,432 billfish during 7,241 fishing days. The annual mean CPUE (measured in catch per day of fishing) for all billfish was 0.61 billfish per day in 2000. This was an improvement over 1999 (0.48 billfish per day), as anglers in 2000 fished fewer days and caught more fish. The 2000 mean catch rate of 0.61 billfish per day is also greater than the prior five-year average catch rate of 0.50 (1995-99) and higher than the all-time mean high catch rates that occurred during the first years of this survey (1969-71). The lowest catch rates averaged 0.34 billfish per day during the mid-1970s.

Blue marlin - Reported catch of blue marlin off Hawaii totaled 480 blue marlin in 3,399 days of fishing, a catch rate of 0.14 blue marlin per day. The Hawaii catch rate has remained fairly constant within a 20-year range. The catch off Baja California, Mexico, totaled 70 blue marlin in

1,275 days fishing (0.05 fish per day), consistent with prior years. Catch rates of blue marlin off Costa Rica (0.20), Mauritius (0.43), and Tahiti (0.23) also remain consistent with recent results.

Striped marlin - Trends in mean angler catch rates for striped marlin in southern California (0.07) and Hawaii (0.06) declined slightly in 2000 but have remained fairly consistent since the mid-1980s. At the southern tip of the Baja California peninsula (north of Mazatlan), 921 striped marlin were reported caught in 1,275 days of fishing. This catch rate of 0.71 striped marlin per angler day was slightly more than the catch rate for all of Mexico (0.63). Baja California is a core area for billfish abundance and has always been a productive area for striped marlin. There appears to be no long-term trend for the period, although several periods of highs and lows are evident. For example, periods of lower catches off Mexico occurred during or immediately following strong El Niño episodes (1982-83, 1987, 1991-92, and 1997).

Black marlin - Reported catch rates of black marlin in Australia (0.23) and Panama (0.22) increased in 2000 but are below recent highs.

Sailfish - Catch rates of sailfish throughout Mexico (0.30) did not reflect the greater success rates off the central coast from Mazatlan to Zihuatanejo (1.45). Catch rates there were generally better than in recent years. Guatemala beat all records, with 1,257 sailfish reported in just 123 days of fishing (10.22), and Costa Rica rebounded from a three-year decline in angler success with a catch rate of 2.04 sailfish per angler day. Anglers in the Indian Ocean reported 0.72 sailfish per angler day, with excellent fishing in Kenya (0.86) and the Maldive Islands (0.85).

Spearfish - Shortbill spearfish continued a strong run off Hawaii, where anglers reported catching 302 shortbill spearfish in 3,399 fishing days, for a catch rate of 0.09 fish per day.

The Billfish Tagging Program – The Billfish Tagging Program uses release and recapture data from tagged billfish to determine the movement patterns, geographic distribution, and growth patterns of billfish. More than 47,610 fish of 76 different species have been tagged and released under this program since its inception in 1963.

The billfish tagging report cards received for the year 2000 indicate a total of 636 billfish were tagged and released by 436 anglers and 173 fishing captains. This is 6% fewer tag releases than in 1999 and 34% fewer tag releases than in 1998. Only 38 striped marlin were tagged off southern California. In Hawaii, 121 blue marlin and 65 striped marlin were reported tagged and released. The year 2000 was another good year for tagging short-billed spearfish in Hawaii, where 85 were tagged. The number of taggings off Mexico remained similar to past years, with 182 billfish tagged from Magdalena Bay south to La Paz and 91 more billfish tagged between Mazatlan, Zihuatanejo, and Acapulco. Eight swordfish were tagged off Mexico during the year.

Tag Recoveries in 2000 - Seven billfish were reported recaptured in 2000, including three blue marlin and four sailfish. Two of the recaptured blue marlin were tagged off Kailua-Kona, Hawaii, and one off Lanai, Hawaii. Two of the blue marlin were recaptured by longline fishers and one by trolling. One of these marlin was at liberty for 1,288 days (3.5 years), during which time it traveled across the International Date Line, where it was recaptured near the Marshall Islands, a distance of 1,769 nmi. Two of the sailfish were tagged and recaptured near Zihuatanejo, Mexico. The other two sailfish were recaptured near Abu Dhabi, United Arab Emirates, in the Persian Gulf, where they were tagged in 1998. One sailfish was free for 1,148 days and traveled

northwest 305 nmi. To date, Iranian fishermen have reported recapturing 14 of the 96 tagged sailfish from the Persian Gulf.

Two tagged bluefin tuna also were recaptured in 2000. Both fish moved north from Isla Cedros off Baja California to just south of Ensenada, Mexico, in 386 and 389 days, presumably after making a trip to the western Pacific and back. Other nonbillfish tag recaptures included three common thresher shark and two shortfin mako shark tagged during the SWFSC's annual shark abundance survey.

Survey of Southern California Billfishing Clubs —The fishing records from three southern California sportfishing clubs (Balboa Angling Club, San Diego Marlin Club, and the Tuna Club of Avalon) were collected in 2000. The combined records from the three clubs provide seasonal data on catch and size of catch for southern California striped marlin, swordfish, and tuna taken by club members during nearly 100 years of recordkeeping. Information and data collected by the clubs did not include measures of fishing effort such as number of anglers or number of days fished.

Members of the three clubs recorded 577 swordfish taken off southern California between 1909 and 1996. Club data ranged from zero catch in several years to a peak of 127 swordfish reported in 1978. Periods of greatest swordfish catch occurred between 1915 and 1930 and from 1969 to 1981. The increased catches during the 1970s correspond to a similar increase in landings from California's commercial harpoon fishery and may reflect a generally higher abundance of swordfish in southern California waters. Greater swordfish abundance coincided with warm periods associated with El Niño episodes.

The mean whole weight of the recreationally caught swordfish recorded between 1909 and 1996 was 116 kg or 255 lb. The documented weight of the swordfish taken by club members declined to 105 kg (231 lb) during 1986 to 1996 from 120 kg (265 lb) during 1909 to 1916.

Reported striped marlin catches from all three clubs (including landed, tagged, and released fish) totaled 28,929 fish and ranged from 273 fish per year in the 1990s to 761 fish per year during the 1980s. The period between 1955 and 1965 had some of the highest catches in a single season, although the 1980s had more consistent catches. The mean whole body weight of 21,501 striped marlin weighed at the sportfishing clubs from 1903 to 2000 averaged 68 kg (150 lb) and individual weights ranged from 22 kg to >180 kg (48 lb to >400 lb). Larger striped marlin were taken off southern California through the 1940s than in subsequent years. The average weight of striped marlin from 1910 to 1915 declined from 83 kg (182 lb) to 57 kg (126 lb) during 1995 to 2000. There are no records of striped marlin in excess of 160 kg (350 lb) landed off southern California since the 1950s. Although early weight records possibly include a few blue marlin and swordfish incorrectly identified as striped marlin, those few numbers will not change the fact that the size of striped marlin caught off southern California declined significantly over the period covered by club records. Club records also document a substantial increase in tag-and-release fishing. The number of striped marlin released and/or tagged increased from between 20% to 50% in the 1980s to nearly 90% in recent years.

PacFAAB Activities – The Pacific Federal-Angler Affiliation for Billfish (PacFAAB) is a cooperative effort between fishery scientists and recreational billfish anglers to improve Pacific billfish stock assessments with new data on billfish movements, growth, reproduction, and tagging mortality. Collaborative projects will help acquire specific billfish life history data, time

series abundance estimates, movement patterns and stock boundaries, and measures of the physical condition of fish at time of release.

A number of PacFAAB activities were undertaken in 2000. A new Internet site went online (http://swfsc.nmfs.noaa.gov/frd/PacFAABa.htm) to help make billfish research results available to anglers on a timely basis. A volunteer bridge log was developed for time-series indexing of recreational billfish CPUE. Better documentation of length of catch records was achieved, and historic records were obtained from angling clubs for time-series indices of billfish abundance. A program was started to update billfish tournament recordkeeping to include measures of total fishing effort. In addition, a program was started to obtain billfish tissue samples for genetic and physiological studies.

VII. OTHER ACTIVITIES

Management Plan for Pacific Highly Migratory Species – A team consisting of staff from state agencies and the NMFS is continuing to work with conservation groups and the fishing industry on developing a fishery management plan for U.S. west coast Pacific highly migratory species. An advisory panel of stakeholders is providing additional input. Although development of the plan is proceeding smoothly, the original completion date has been postponed until September 2001 to allow time to complete the required analyses, investigate advisory subpanel recommendations, and accommodate requests for public comment. When completed, the plan will ensure coordinated data collection and provide for management of highly migratory species throughout U.S. waters in the Pacific Ocean. The plan also will address specific issues affecting Pacific highly migratory species, such as overfishing, bycatch, prohibited species, essential fish habitat, and interactions with foreign fleets.

SCTB Annual Meeting – The annual meeting of the Standing Committee on Tuna and Billfish (SCTB) was held in Noumea, New Caledonia, in July 2000. Scientists attending the meeting presented working papers on the biology, fishery statistics, and stock assessment of Pacific tuna, billfish, and shark stocks.

An initial overview of central and western Pacific tuna fisheries noted that the estimated total catch in 1999 for the four main tuna species was 1,716,806 mt, the second highest total catch on record after 1998 (1,893,648 mt). The 1999 catch of skipjack tuna (1,104,121 mt) was slightly down from the record level of the previous year (1,242,45 mt), and as usual skipjack dominated the total tuna catch (64%). Yellowfin tuna (393,998 mt) and South Pacific albacore (38,425 mt) catches also were slightly down from 1998 levels, but bigeye tuna catch increased (102,295 mt) and was just under the record high (104,558 mt) taken in 1997. National fishery reports provided further details of these catches. The U.S. national report, authored by SWFSC staff, contained catch and other fishery statistics for the U.S. tuna purse-seine, troll, pole-and-line, and longline fisheries operating out of ports on the U.S. west coast, Guam, American Samoa, Northern Marianas, Federated States of Micronesia, and Hawaii.

The meeting saw, for the first time, application of the Multifan-CL length-based stock assessment model to all four target tuna species in the central and western Pacific and to North Pacific blue shark. A working group was established to provide technical advice to the SCTB on this and similar methods.

ISC Bluefin Workshop – The Interim Scientific Committee for Tuna and Tuna-like Species in the North Pacific Ocean (ISC) held a workshop on North Pacific bluefin tuna in Shimizu, Japan, November 20 and December 1, 2000. Scientists from Japan, Korea, Mexico, the United States, and the IATTC participated. The participants reviewed fisheries data and the latest developments in the fisheries, along with results of studies ranging from archival tagging to stock assessment using variable population analysis. The overall objective was to determine the condition of the stock and to develop research plans to improve the determination, if uncertain.

The participants concluded that considerable progress has been made in understanding the biology of bluefin tuna, in assembling a long time series of data, and in analyzing data with traditional assessment techniques. However, the condition of the stock is still uncertain and additional investigations need to be carried out before there is sufficient assurance that assessment results are reliable. For example, investigations are needed to validate assessment results that show spawning stock biomass has been increasing during the last decade and is currently at mid-range of highest and lowest historical stock biomass. Also needed are investigations to determine gains in sustainable yield if fishing mortality on young (0- to 4-year-old) fish is reduced. Current assessment results indicate that yield per recruit could be increased by decreasing fishing mortality on young fish.

The participants prepared a research work plan along with a meeting report. Both are to be submitted to the ISC when it meets in 2001.

VIII. SWFSC PUBLICATIONS ON TUNA AND TUNA-RELATED SUBJECTS

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